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THE CHANGE OF BLOOD SERUM CONCENTRATION AFTER WATER INTAKE

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In their refractometric blood serum investigations, Strauss and Chajes found a very significant decrease in blood serum concentration after water intake. This decrease had already begun 15 minutes after 1 liter of water had been introduced into the stomach by tube. It increased rapidly and still persisted 1 1/2-2 hours later. Five experiments were performed on three persons. The most significant decrease occurred in two experiments carried out on the same patient. The refraction coefficient fell from 1.3500 to 1.3471 in one experiment and from 1.3501 to 1.3476 in the other. In the other experiments, the decrease was much less pronounced. These results were considered striking by the authors, and we feel that they are highly surprising. In the first case, for example, the decrease in the refraction coefficient corresponds to a 22 percent decrease in total blood serum albumin. Since we know the osmotic stability of the blood and the effort of the organism to maintain both the normal volume of blood and the normal serum albumin contents, it is surprising that the regulative system of the otherwise healthy organism should be unable to maintain this equilibrium in the face of such relatively slight interference.

The findings of Strauss and Chajes are even more striking since the same experiments using different methods have yielded different results. For example, Nasse and Schulze in their older experiments, and Lichtheim, who allowed his patients to drink 21.5 liters of distilled water during a three-day period, were unable to prove any blood dilution. On the other hand, Buntzen found that a dog's red corpuscles decreased 5.4-12.7 percent after copious intake of water. Schmaltz, who made pyknometric determinations of the specific gravity of blood, found that it decreased in one case from 1.0597 to 1.0574 within 3/4-hour after the intake of 1 liter of physiological saline. In another experiment, the specific gravity fell from 1061 to 1057 after intake of 3/4 liter of physiological saline. The author remarked that the initial value in this case was quite high (1061).

The importance of this question led us to pursue it during our refractometric studies. Since we wished to conduct our experiments on healthy persons, at least with respect to resorption, circulation and secretion, we could not use Strauss and Chajes' method of introducing water into the stomach by tube. We allowed the subjects to drink it.



To make this easier we used the alkaline mineral water Salvator, which agreed with the patients much better than did corresponding amounts of plain water (900-1400 cc). More carefully, we extracted blood from the same two capillaries in each instance and used the contents of both tubes in our studies.

In order to achieve the same exactness as was achieved in the refractometric measurements, we followed the same procedure in our specific gravity and red blood count determinations.

The results obtained in experiments on five healthy subjects and one patient suffering from cystitis tuberculosa (with normal urine volume) are presented in the tables for Experiments I-VI.

An examination of the tables shows that we found no concentration decreases as large as that determined by Strauss and Chajes. In some cases a quite unexpected result was obtained. Although we allowed the subjects to drink far more than 1 liter in some instances (3 bottles of Salvator = 1350-1400 cc), we found not only no decrease in the refraction coefficient, but rather that it increased to a maximum and then returned to approximately the initial value. When we compared the refraction coefficient of the blood serum with urine volume, as well as with its freezing point, we observed in Experiment I that the refraction coefficient was highest--1.3503--at a time when urine volume was greatest and lowering of the freezing point least (400 or 500 cc during a 20-minute period with a Δ of 0.16, 0.15 respectively).

This coincidence of the highest refraction coefficient with secretion of the most highly diluted urine, as well as with its greatest volume, was also noted in Experiments II and IV. The same phenomenon was observed, however, in instances where the refraction coefficient decreases initially and then begins to increase, as in Experiment III and as also indicated in Experiment VI. This finding warrants special attention. One might well expect hydremia to occur when the water in the intestinal tract is resorbed. The regulative function of the kidneys should then take effect when the hydremia reaches a certain point. The above finding seems to contradict this hypothesis, since an increased blood concentration exists at the time of greatest urine flow. Furthermore, this condition does not last for minutes, but for a significantly longer period. To explain this finding, several possibilities must be considered. For one, the kidneys may draw off water from the blood at a time when water is in the stomach or intestines and no resorption of it has taken place. We should have to assume either a gastrosrenal or intestinorenal reflex. The fact that the greatest flow of urine occurs 75-80 minutes after the intake of water, when part of it must already have been resorbed, speaks against this assumption.

Experiment I				Experiment II			
Epilepsy. 3 bottles of Salvator Water intake 10:20 to 10:40 a.m.				Epilepsy. 2 bottles of Salvator Water intake 9:15 to 9:25 a.m.			
Time	Urine Volume	— Δ	Refraction Coefficient	Time	Urine Volume	— Δ	Refraction Coefficient
10:20	---	---	1.3497 1.3498	9:15	---	---	1.3491 1.3489
10:40	120	1.43	1.3498 1.3499	9:30	---	---	1.3495 1.3497
11:00	300	0.23	1.3499 1.3499	9:50	110	1.83	1.3495 1.3497
11:15	400	0.16	1.3503 1.3503	10:10	180	0.32	1.3499 1.3499
11:35	500	0.15	1.3502 1.3503	10:30	250	0.27	1.3493 1.3494
11:55	120	0.49	1.3502	10:50	90	0.74	1.3496 1.3498
12:15	---	---	1.3500 1.3501	11:10	---	---	1.3491 1.3493
12:35	70	1.51	1.3498 1.3498	11:30	80	0.79	1.3494 1.3496

It is therefore more probable that the stability of firstly blood composition and then the supportive tissues play a special role here. A hydremia does occur at the beginning of resorption, but it is usually so slight that it cannot even be measured with the ostensibly sensitive refractometric method. In other cases, however, the hydremia is indicated or even pronounced (see Experiment III). The regulative organs--principally the tissues and kidneys--then function to prevent further hydremia, and as a result of the interaction of these components, the increase in blood serum concentration occurs as hypercompensation. The fact that the kidneys normally accomplish the greater part of this work is proven by the finding that in cases where well water was used instead of Salvator, which has diuretic effects, and the urine flow was therefore not so high, no increase could be observed in the refraction coefficient; rather it decreased steadily, if slightly, and with certain variations (see Experiment V). Our results, however, also show that organs other than the

Experiment III

Epilepsy. 3 bottles of Salvator
Water intake 8:40 to 9:00 a.m.

Time	Urine Volume	Δ	Refraction Coefficient
8:40	120	1.70	1.3508
8:55	30	1.38	1.3509 1.3508
9:10	75	0.42	1.3500 1.3499
9:25	200	0.17	1.3502
9:40	250	0.13	1.3508 1.3509
10:00	360	0.10	1.3506 1.3508
10:20	320	0.11	1.3508 1.3509
10:40	150	0.32	1.3506 1.3507
11:00	60	0.42	1.3506

Experiment IV

Tabes dorsalis. 3 bottles of
Salvator
Water intake 9:30 to 9:50 a.m.

Time	Urine Volume	Δ	Refraction Coefficient
9:30	50	1.61	1.3487 1.3488
10:00	25	1.56	-
10:15	25	1.39	1.3485 1.3487
10:40	50	0.29	1.3489 1.3489
10:55	130	0.29	1.3495 1.3497
11:20	160	0.24	1.3489 1.3490
11:40	50	0.62	1.3488 1.3489
12:05	40	1.21	1.3484 1.3484
12:35	25	1.17	1.3482 1.3484
1:15	40	1.32	-

kidneys take part in the removal of water from the bloodstream and/or the organism.

In Experiment IV, a patient suffering from cortical epilepsy eliminated only 500 cc of urine after the intake of 1300 cc of water. The remaining water must, therefore, have been either retained in the tissues or removed through the sebaceous glands. In spite of this, the refraction coefficient did not decrease. On the contrary, it increased at the time of greatest urine secretion. In Experiment VI the blood serum concentration shows irregular variations--both marked decreases and sudden increases (from 1.3510 to 1.3500, and then to 1.3510). In spite of this irregularity, the coincidence of the greater increase in the refraction coefficient with the highest urine dilution stands out.

Our experiments also included patients with noncompensated heart defects and kidney ailments, where disruptions of the water balance existed (Experiments VI-XII). A sharper decrease in the refraction coefficient could not be determined in any of these cases, although it seemed likely that a greater dilution of blood would occur here as a result of greater water retention. We even found some instances where the blood became thicker in spite of the slight urine secretion (indicated in Experiment IX, pronounced in Experiment X).

Experiment V				Experiment VI			
Tabes dorsalis. 900 cc well water				Cystitis tuberculosa. 2 bottles			
Water intake 9:15 to 9:25 a.m.				Salvator			
				Water intake 9:40 to 10:00 a.m.			
Time	Urine Volume	Δ	Refraction Coefficient	Time	Urine Volume	Δ	Refraction Coefficient
9:15	-	1.69	1.3508	9:40	50	1.11	1.3509 1.3510
9:35	-	-	1.3507 1.3508	10:00	40	0.51	1.3509 1.3511
9:55	35	1.02	1.3506 1.3508	10:20	75	0.30	1.3506 1.3507
10:15	75	0.36	1.3504 1.3505	10:40	75	0.25	1.3507 1.3508
10:35	105	0.25	1.3499 1.3500	11:00	150	0.22	1.3500 1.3501
10:55	200	0.18	1.3503 1.3504	11:20	130	0.19	1.3501 1.3501
11:15	25	0.56	1.3500	11:40	130	0.17	1.3500 1.3510
11:35	25	0.96	1.3500 1.3501	12:00	125	0.21	1.3504 1.3504
				12:20	120	0.20	1.3507 1.3508
				12:40	105	0.24	1.3510
				1:00	5	-	1.3510

The cause of this is obviously that the tissues immediately removed the resorbed water from the blood. This water either increases the already existing hydropsy or is eliminated via the sebaceous glands. This assumption seems to be confirmed by Experiment XI. In this case, 900 cc of water were drunk and only 300 cc of urine were secreted. The body weight measurements proved that only 300 cc of water were retained in the body; therefore, 300 cc of water must have been eliminated through the skin. In Experiment XII, where the patient was in a preedematous condition and had a very low serum albumin content, and where 900 cc of water were ingested and only 250 cc of urine were secreted, the refraction coefficient was unchanged. Beginning on the day of the experiment, a rapidly increasing edema set in.

These results and those obtained in the experiments with patients suffering from diabetes insipidus prove that the corresponding regulative

Experiment VII				Experiment VIII			
Insuffic. bicuspid. c. stenosis. Widespread edema. 2 bottles of Salvator Water intake 9:20 to 9:40 a.m.				Insuffic. bicuspid. c. stenosis. Widespread edema. 2 bottles of Salvator Water intake 10:30 to 10:45 a.m.			
Time	Urine Volume	Δ	Refraction Coefficient	Time	Urine Volume	Δ	Refraction Coefficient
9:20	-	1.46	1.3475 1.3477	10:35	-	1.19	1.3464 1.3466
9:45	15	0.23	1.3479 1.3479	11:10	30	1.59	1.3462
10:20	130	0.16	1.3470 1.3471	11:40	33	0.65	1.3467 1.3467
10:50	150	0.16	1.3476	12:15	-	-	1.3469 1.3470
11:15	40	0.45	1.3470	12:55	42	0.40	1.3469 1.3470
11:35	40	0.36	1.3478 1.3478	11:15	8	-	-
11:55	50	0.34	1.3471 1.3472				

powers of the organism are significant. Even in these cases the blood serum concentration hardly changed, even though water was first denied the patients and then given to them in quantity. These tests are short but quite uncomfortable for the patients, and very significant concentration variations may be caused by this (Strubell). In one case of diabetes insipidus with 18-20 liters of urine daily, the patient secreted 300 cc of urine in a half-hour period during which she received no water and the refraction coefficient increased from 1.3532 to 1.3540. After 1500 cc of water were drunk, it decreased rapidly to 1.3526. In this case, the half-hour water prohibition was so uncomfortable for the patient that she stated that she could have not endured it longer.

Experiment IX

Insuffic. bicuspid. et aortae.
Widespread edema. 2 bottles
of Salvator.
Water intake 10:30 to 10:45 a. m.

Time	Urine Volume	Δ	Refraction Coefficient
10:30	---	1.21	1.3469 1.3470
10:55	10	---	1.3467 1.3468
11:20	28	1.07	1.3461 1.3463
11:45	170	0.37	1.3462 1.3463
12:20	98	0.45	1.3467
12:45	60	0.74	1.3465 1.3465
1:10	65	0.68	1.3467 1.3469

Experiment X

Insuffic. aortae. Nephritis
chronica. 2 bottles of
Salvator.
Water intake 9:35 to 9:50 a. m.

Time	Urine Volume	Δ	Refraction Coefficient
9.35	40	1.77	1.3489 1.3491
10:15	20	1.77	1.3492 1.3492
10:45	100	0.41	1.3498 1.3498
11:20	200	0.21	1.3502 1.3502
11:45	60	0.61	1.3495 1.3496
12:15	20	1.17	1.3491 1.3492

Experiment XI

Nephritis chronica. 2 bottles
of Salvator.
Water intake 9:45 to 10:00 a. m.
Body weight at 9:37 a. m.: 49.66 kg

Time	Urine Volume	Δ	Refraction Coefficient
9:37	---	1.75	1.3459 1.3460
10:03	12	1.59	1.3463
10:25	12	1.46	1.3458 1.3466
11:00	90	0.43	1.3460 1.3461
11:30	100	0.37	1.3461 1.3459
11:55	35	0.56	1.3461 1.3461
12:30	45	0.70	1.3459 1.3459

Body weight at 12:30 p. m.: 49.97 kg

Experiment XII

Nephritis chronica. 2 bottles
of Salvator.
Water intake 9:35 to 9:50 a. m.

Time	Urine Volume	Δ	Refraction Coefficient
9:35	---	2.10	1.3428 1.3430
10:10	25	1.55	1.3431 1.3432
10:45	100	0.37	1.3428 1.3430
11:15	80	0.54	1.3430 1.3432
11:45	20	1.35	1.3430 1.3430
12:15	20	0.99	1.3429 1.3429

Experiment XIII

Diabetes insipidus.

Patient received no water from 8:30 to 9:00 a. m.
3 bottles of Salvator administered at 9:00 a. m.

Time	Urine Volume	Refraction Coefficient
8:30	---	1.3531 1.3534
9:00	300 0.18	1.3538 1.3540
9:30	460 0.19	1.3526 1.3528
9:55	390 0.17	1.3527 1.3527
10:25	320 0.17	1.3532 1.3532

Our final results may be summarized as follows. Even copious water intake will cause no sharper decrease in blood serum concentration, whether among those with healthy kidneys or those whose water balance is disrupted. No significant hydremia can be proved even after a very large urine secretion consequent upon such intake. On the contrary, and increase in blood serum concentration may sometimes be determined during the time of greatest diuresis, both in healthy subjects and in patients with disrupted water balances.

References

1. Grawitz, Klinische Pathologie des Blutes (Clinical Pathology of the Blood). Berlin, 1902.
2. Strauss and Chajes, Refraktometrische Eiweissbestimmungen und ihre klinische Bedeutung (Refractometric Protein Determinations and Their Clinical Significance). Zeitschr. f. klin. Med. Vol. 52.
3. Strubell, Klinische Untersuchungen über Diabetes insipidus (Clinical Examinations of Diabetes insipidus). Deutsches Archiv f. klin. Med. Vol. 68.

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